



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

ATLANTIC VS. PACIFIC ELEVATIONS IN KANSAS.

BY H. V. HINCKLEY, B. S., M. AM. SOC. C. E., TOPEKA.

[This article is substantially a reproduction of one read before the American Society of Civil Engineers, March 3, 1886.]

Our meteorological records, the study of our climatology, and our astronomical observations and the general advancement of science, demand, in the interest of accuracy, a more thorough knowledge of our elevations above the sea. An astronomer about to observe the transit of Venus, asked of me the height of his point of observation, saying that it was necessary for his calculations that he have the elevation stated above mean tide within a possible limit of error of five feet. I gave him elevations from both oceans according to my own figures, (the two heights differing from each other less than three-quarters of an inch,) and stated to him that the highest authority on elevations (Henry Gannett, Ch. Geographer of the U. S. Geolog. Survey) would tell him that neither elevation was within thirteen feet of correct. My reason for this statement will appear near the close of this paper.

The Government has been constantly at work on elevations throughout the country, especially sites of signal stations and meteorological observations. The height of Pike's Peak has been determined several times by barometer and triangulation, and later by check levels to settle a discrepancy of a very few feet, and to obtain, with the greatest possible accuracy, the elevation of the signal station above mean tide; and yet to this day, neither the Coast Survey, the Geological Survey, nor the Signal Service, can tell from actual determination the difference between the mean tide elevations of the two oceans on the United States coasts, or whether any such difference exists. The determinations of the greater part of the elevations in the United States have been first by barometer, and afterward by railroad levels or other more reliable authorities. The inaccuracy of the barometer, even when all known corrections have been applied, and the careless and incorrect reports of elevations from the profiles of the railroads, have caused much annoyance in the geographical department of the Geological and Geographical Survey at Washington.

The "Lists of Elevations" collated by Mr. Gannett, and published in 1877 by the U. S. Geological Survey, contains, on page 20, a reference to the A. T. & S. F. R. R. levels, founded upon statements obtained from that road, and which reads as follows: "On account of the character of the leveling between Topeka and Kinsley, this line is valueless as a check." Corrections of 18 to 68 feet were made by Mr. Gannett upon the elevations, furnished from the profiles of different parts of the road. I first noticed this in 1882, and, believing that errors of such magnitude in location levels could hardly have been embodied in the construction-work without being detected by either leveler or locomotive, I determined to test the correctness of the levels upon the A. T. & S. F. R. R. by carefully searching for breaks in datum planes, making the proper corrections for all parts of the various lines, and obtaining such checks as might be obtainable from intersecting roads and reliable benches, in order to determine whether the discrepancies and necessary corrections reported back by the Government were due to the general unreliability of the railroad levels, or to improper reports to the Government officers of unadjusted elevations; and in order to avoid, if possible, a continued confusion and doubt as to elevations of prominent points, and, in fact, of nearly every station along the Santa Fé line.

Under authority from A. A. Robinson, Sec., V. P. and Ch. Engr., I have compiled a profile of the entire A. T. & S. F. system of roads, from the Missouri river to the Gulf of California, at a cost of over a thousand dollars. This profile gives the corrected elevation of every station on the line, being that of the top of rail at east end of depot

in each case where a depot exists; and the elevations have been carefully figured to a thousandth of a foot in all cases, not to indicate that the track is everywhere so true to its original grade, but in order that my results, and any work that may in future be based upon my results, may be correct to the extent of the information at my command. My elevations east of the Continental Divide I have figured from Atlantic "mean tide," and are based upon a United States bench on the face of the south abutment of the Hannibal & St. Joseph Railroad bridge, over the Missouri river, at Kansas City. The elevation of this bench was taken, 428.29 (St. Louis Directrix, by James T. Gardner, in "Elevations of Datum Points," 1875) +341.394 (furnished me by Wm. B. Knight, City Engineer of Kansas City, Nov. 2, 1882) =769.684. My elevations west of the Continental Divide are above Pacific "mean tide" at Guaymas, Sonora, Mexico, taken as 0.625 feet below Guaymas "mean high tide," (from data furnished by T. J. Seely, Asst. Gen. Manager Sonora Ry., Feb. 9, 1883.)

The following checks, numbered 1, 2, 6, and 8, were obtained before the completion of the profile, and the others are the result of later investigation:

CHECKS.

1. Elevation carried from Kansas City to Atchison via Topeka compares with elevation taken from U.S. bench at Atchison Union Depot, +0.006 of a foot. Length of circuit, 173 miles. Length of railroad levels, 116 miles.

2. Elevation carried from Kansas City to Emporia Junction compares with elevation carried from Kansas City via Topeka, North Topeka and Junction City, over the Union Pacific and Missouri Pacific railroads to Emporia Junction, +0.180 of a foot. Length of circuit, 296 miles.

3. Elevation carried from Kansas City via Albuquerque and the Atlantic & Pacific R. R. to the Colorado river compares with Southern Pacific elevation brought from San Francisco, (based upon Fort Point high-water datum, and corrected, -1.790 feet; per data furnished by the Signal observer at San Francisco, Oct. 22, 1883.) -2.040. Length of railroad levels, 2,115 miles.

4. Elevation carried from Kansas City via Albuquerque, Mojave and Yuma, over the Atlantic & Pacific and Southern Pacific roads to Port Ysabel, at the head of the Gulf of California, compares with mean tide at that point, -1.03 feet, (+2.80, S. P. reading at Port Ysabel per Geo. E. Gray, Ch. Engr., -2.04 per check No. 3, -1.79 S. P. correction also given in check No. 3.) Length of railroad levels, 2,149 miles.

5. Elevation at East Pueblo crossing of A. T. & S. F. R. R. and D. & R. G. Ry. compares with elevation carried from Kansas City to El Moro and thence over the D. & R. G. Ry. via South Pueblo, -0.580 of a foot. Length of railroad circuit—Pueblo, La Junta, El Moro, Pueblo—246 miles.

NOTE.—I have no less than six checks upon Pueblo via Denver, covering a range of 26 feet. The indefinite way in which these have been reported to me destroys my confidence in them all, especially as none of them agree with my results, while my check No. 5 proves the correctness of my results upon the Pueblo elevation within 7 inches. I must quote here from Gardner's "Elevations," (page 631): "I am satisfied that the important errors in our railroad and canal profiles are not so much due to imperfect instrumental work as to hasty and careless combination of the results." It would also be proper to state here that I have checked upon the St. Louis & San Francisco Railroad, at Augusta Crossing and North Wichita Junction, their elevations being carefully given to me by James Dun, Chief Engineer, and my results comparing with his at those two points, -7.212 and -7.882 respectively. Elevations of both roads being based upon the same elevation of St. Louis Directrix, and the results being therefore independent of the absolute height thereof. I should also state that Chief Engineer Perris, of the California Southern Railroad, has carefully reported to me two checks of his road upon the Southern Pacific Railroad, as follows, (Nos. 20 and 21:)

20. Elevation carried from San Diego over the California Southern Railroad to Waterman by location levels, compares with Southern Pacific elevation from San Francisco +1.801 feet.

21. Elevation carried from San Diego over the California Southern Railroad to Waterman by check levels, compares with Southern Pacific elevation from San Francisco $+3.684$.

6. Elevation at Deming compares with Southern Pacific elevation, corrected as in No. 3, -0.062 of a foot. Length of railroad levels, 2,347 miles.

7. Elevation from Deming carried via Southern Pacific Railroad and Yuma to Port Ysabel compares with mean tide at that point ($2.80 - 1.79 - 0.062$) $+0.948$ of a foot. Length of railroad levels, 1,685 miles.

8. Elevation at Continental Divide (about 40 miles west of Deming and upon a stretch of 173 miles of unconstructed line) compares with "mean tide" elevation brought from Guaymas, $-3,390$ feet. Length of railroad level, 1,657 miles.

9. Elevation at the Southern Pacific overhead crossing of the A. T. & S. F. R. R. near El Paso compares with the Southern Pacific elevation at the same point (brought from San Francisco and corrected as in No. 3,) $+0.128$ of a foot, (from data secured by S. P. R. R. during construction,) and $+0.460$ of a foot, (from data secured by A. T. & S. F. R. R. four years later.)

NOTE.—The A. T. & S. F. determination was merely as a second or double check, and the difference between the two checks (about 4 inches) I attribute to four years' settling of the overhead crossing trestle. For correct results, therefore, I use the first comparison in No. 9, and discard the second.

10. Elevation at Deming compares with elevation carried from Albuquerque over Atlantic & Pacific & Southern Pacific railroads via Mojave to Deming ($2.04 - 0.062$) $+1.978$ feet. Length of circuit, 1,862 miles.

11. Elevation at Rincon compares with elevation carried from Rincon via Deming and El Paso crossing back to Rincon, $+0.190$ of a foot. Length of circuit, 218 miles.

I had thought I should be doing well if I secured a transcontinental check within 10 or even 20 feet, or if I secured a check upon any reliable bench east of the Continental Divide within 10 feet. The first, closest and most reliable check obtained was No. 7; and it was generally looked upon as a remarkable coincidence, if not possibly a "manufactured" check, and I little expected to have it so closely supported by the ten other checks above given. All the old field-note books and profiles were diligently searched for breaks, and all the checks here given are substantiated by documents on file in my office. Summarizing, first those lines which are all rail, or upon which level checks level, and assuming absolute accuracy in the U. S. levels between the Kansas City and Atchison benches, we have the following table of—

RAIL CIRCUIT CHECKS.

No.	From	Via	To	Miles.	Errors in feet.	Errors, feet per mile.	Errors, inches per mile.
1.....	Kansas City.....	Topeka.....	Atchison.....	116	0.006	0.00005	0.00060
2.....	Emporia Junc...	N. Topeka and Junction City ...	Emporia Junc...	196	0.180	0.00092	0.01104
5.....	Pueblo	La Junta and El Moro	Pueblo	246	0.580	0.00236	0.02832
10.....	Deming	Albuquerque and Mojave	Deming	1,862	1.978	0.00106	0.01272
11.....	Rincon	Deming and El Paso.....	Rincon.....	218	0.190	0.00087	0.01044

Next summarizing the checks furnished by the assumption that the mean tides of the two coasts have a common elevation, and that Gardner's Atlantic elevation of Kansas City as above stated is correct, the later levels of the Mississippi River Commission and Coast Survey to the contrary notwithstanding, and throwing check No. 8 out of the general results on account of the unreliability of 173 miles of unchecked preliminary mountain levels, we have the following table of tide checks:

TIDE CHECKS.

No.	From	Via	To	Miles.	Errors in feet.	Errors, feet per mile.	Errors, inches per mile.
3.....	Kansas City....	A. & P. R. R.....	San Francisco....	2,115	2.040	0.00096	0.01152
4.....	Kansas City....	A. & P. and S. P.,	Port Ysabel.....	2,150	1.030	0.00048	0.00576
6.....	Kansas City....	Deming	San Francisco....	2,347	0.062	0.00003	0.00036
7.....	Kansas City....	Deming	Port Ysabel.....	1,686	0.948	0.00056	0.00672
8.....	Kansas City....	Tombstone.....	Guaymas.....	1,657	3.390		
9.....	Kansas City....	El Paso.....	San Francisco....	2,459	0.128	0.00005	0.00060

NOTE.—Lieut. Gardner, in his “Elevations of Datum Points,” 1875, (pages 643, 644 and 653,) reports errors as follows:

- (a) 9.9 feet, Portland to New Orleans via Chicago, 2,100 miles, or 0.0048 feet per mile.
- (b) 2.44 feet from New York Bay to New Orleans via Chicago, 1,800 miles, or 0.0013 feet per mile.
- (c) 4.61 feet, Raritan Bay to New Orleans via Chicago, 1,800 miles, or 0.0025 feet per mile.
- (d) 25.0 feet, Portland to San Francisco via Chicago, 3,500 miles, or 0.0071 feet per mile.
- (e) 26.0 feet, New Orleans to San Francisco via Kansas City and Denver, 3,200 miles, or 0.0081 feet per mile.

Mr. S. D. Mason, Principal Asst. Engr. N. P. R. R., under date of Nov. 19, 1885, reports an error of “about 4 feet,” (not yet definitely determined,) from Lake Superior, at Duluth, to Commencement Bay, at Tacoma, 2,033 miles, or 0.00185 feet per mile. The correctness of my results within the limits of my stated errors is not corroborated by these errors reported from other roads, as they have no bearing upon the St. Louis Directrix or any of my elevations, and are given here merely for a comparison of errors per mile in levels.

By the close results which have been obtained I am convinced that the necessity for the excessive corrections applied by Mr. Gannett arose from the elevations reported to him not having been corrected for breaks in datum planes. I do not offer my results as evidence that railroad levels in mountainous regions are generally to be depended upon within a hundredth of an inch per mile, nor would I intimate that the close results over these particular circuits and check lines from the Missouri river to the Pacific ocean prove the correctness of the old elevation of St. Louis (428.29) and the Missouri river benches at Kansas City and Atchison, as stated by Gardner in 1875, from Atlantic tide points; but in view of the fact that the recent levels of the Coast Survey and Mississippi River Commission tend to lower the elevation of St. Louis and neighboring points 13 and 15 feet respectively, the results given in the second table above, and based upon Gardner's St. Louis datum, are of special interest at this time, for to reduce St. Louis 15 feet would be to make the “errors in feet” in my second table range from 13 to 19 feet.

By using the Atlantic mean tide benches established in the Missouri river valley twelve years ago and the most reliable line of railroad levels which I have at command, and which has but one break, I check from ocean to ocean (mean tide to mean tide) within three-quarters of an inch; and now come the Mississippi River Commission and Coast Survey with their “levels of precision” and say the old benches were too high by 15 and 13 feet respectively. I append Mr. Gannett's letter of Oct. 20, 1883:

DEPARTMENT OF THE INTERIOR, UNITED STATES GEOLOGICAL SURVEY, }
WASHINGTON, Oct. 20, 1883. }

Mr. H. V. Hinckley, Office Engineer A. T. & S. F. R. R.—DEAR SIR: I am in receipt this morning of your communication of the 12th, containing your list of carefully-determined elevations upon the line of your road. Allow me to thank you in the warmest possible terms for this favor, and to assure you that the fullest credit will be given for this valuable piece of work. I am very much puzzled about this change in the St. Louis Directrix, and the consequences it involves. There can be no mistake about the figures as I have received them from the Secretary of the Commission, and the change which this makes is corroborated by the corresponding changes in the heights of Cairo and other points below on the river, the heights of which were received from the Secretary of the Commission at the same time. On the other hand, the checks westward from Kansas City are thrown into confusion not only upon your road but upon other lines. Very truly yours,

HENRY GANNETT,
Chief Geographer U. S. G. S.

I have been unable, up to this time, to secure from our Mexico roads or from Nicaragua or Panama any reliable statement as to the comparative elevations of the two oceans, but I believe there can be no appreciable difference except it be local affected by contour of coast or possibly by winds and ocean streams. See letters from the Chief Geographer and Supt. C. & G. Survey, below:

DEPARTMENT OF THE INTERIOR, UNITED STATES GEOLOGICAL SURVEY, }
WASHINGTON, April 18, 1885.

Mr. H. V. Hinckley, Office Engineer A. T. & S. F. R. R., Topeka, Kansas—DEAR SIR: If there is any difference in level between the Atlantic and Pacific oceans, it is too small to be indicated by levels of such a character as those run by our inter-oceanic canal expeditions. I have not learned anything concerning this point from the work now progressing upon the Isthmus of Panama. I feel, however, confident that the difference, if any, is very small. Very truly yours,

HENRY GANNETT,
Chief Geographer U. S. G. S.

U. S. COAST AND GEODETIC SURVEY, WASHINGTON, June 26, 1885.

H. V. Hinckley, C. E., Topeka, Kansas—DEAR SIR: I have taken great interest in your important letter of the 23d, relating to the difference of level between the Atlantic and Pacific oceans. I trust that you will print your study in detail in the Journal of the American Society of Civil Engineers, and I will be very glad to print it likewise in the Coast Survey Report. The agreement of the several values is certainly unexpectedly close. I nevertheless do not think that the difference of the mean level of the oceans will be found so large by accurate operations. That which you give for San Francisco would, of course, be extremely acceptable. I do not think there can be any such thing as rotational difference of level between the two oceans, but the mean value of *what we are able to observe by means of spirit or water levels is the resultant of the constant forces, and, whatever may be the figure of equilibrium, it is just that which the level indicates.* When we observe a difference, then, it must be owing to dynamic effects of currents and winds. I have thus found the level of the Gulf of Mexico, in the neighborhood of the Balize, to be about forty (40) inches higher than that of the Atlantic ocean at Sandy Hook. That such an elevation must exist is plain enough, from the fact that the water runs from the Gulf of Mexico into the Atlantic ocean; but how much it is, is a question that must be solved by accurate leveling, and a verification is still in progress.

We have not yet extended our line of levels of precision to the Pacific ocean, but will proceed with it in the autumn. I do not know the difference of level between the two oceans at any point. I have always understood that the levels for the Panama Railroad showed that there was no appreciable difference between mean tides. . . . I shall be glad to hear from you again on the subject.

Yours truly, J. E. HILGARD, *Supt. U. S. C. & G. S.*

So that for the present I shall contend that my elevations are correct, and that the corrections of Mr. Gannett, in his 1884 edition of "Dictionary of Elevations," upon the A. T. & S. F. system, are unmerited, even though his precise information to the contrary warrants, on his part, the corrections he now makes. Therefore the question of sea elevations in Kansas must remain "at sea" to the extent of from 1 to 15 feet, or even more, depending on the locality, until the "levels of precision" shall cross the continent, or perhaps till I may earlier obtain checks enough from Texas and Mexico ports to prove the correctness of my apparently very correct results.

NATURAL GAS IN EASTERN KANSAS.

BY ROBERT HAY, U. S. G. S.

[N. B.—The paper with this title which was read at the Emporia meeting was much longer than the following. The introductory part, relating to the development of natural gas in Pennsylvania and elsewhere, has been almost altogether omitted, the more scientific part remodeled, and some additional facts given which became known only a little while before going to press. The paper as read at Emporia appears almost in its entirety in the Fifth Biennial Report of the State Board of Agriculture, whose widespread distribution will bring it within the reach of nearly all the citizens of the State.]

A single company at Pittsburgh, Pa., has a capital of five million dollars invested in procuring and distributing for use the new fuel named usually natural gas. Altogether, the natural gas companies of Pennsylvania employ an aggregate capital of more than twenty millions of dollars. At Wheeling in West Virginia, Findlay in